Efficient High Fidelity Computational Tool for Acoustically Driven Multiphysics Propulsion Modeling, Phase I

Completed Technology Project (2016 - 2017)

Project Introduction

It is widely recognized that detailed simulation of large combustors to assess combustion instability and water spray systems to suppress rocket launch and test stand acoustic energy require advances in two phase flow, combustion, unsteady flow and acoustics modeling efficiency and fidelity. With recent advances in computer science technology, turbulent multiphysics modeling and high fidelity algorithms, current applications are poised for coordinated integration into a computational framework that offers realistic simulation of propulsion system fluid dynamics. MSU has recently implemented a hybrid 4th order skew symmetric flux in the Loci/CHEM multiphysics CFD solver. The new scheme has exceptionally low dissipation properties for vortical and acoustic signal propagation on both structured and unstructured meshes and offers excellent potential for analysis of acoustically driven propulsion system combustion instabilities. Simulation of large scale systems, however, is further complicated by the need to model unsteady turbulence effects. MSU has also recently employed the very promising dynamic hybrid RANS/LES methodology with the new low dissipation scheme to demonstrate significantly improved resolution of fine scale unsteady turbulence structures. For highly stretched boundary layer meshes, however, both implicit and explicit time integration schemes are problematic for thin boundary layers. Fortunately, dramatic performance improvements are possible through a novel hybrid explicit-implicit time integration scheme that uses the implicit treatment for fluxes constrained by the explicit stability limit and the explicit scheme elsewhere. Since the explicit method is more than an order of magnitude cheaper than the implicit scheme, the potential speedup could be a factor of ten. Thus the proposed computer science, turbulent multiphysics and high fidelity integrated framework can realistically expect to enable propulsion system DDT&E and production cost reductions.

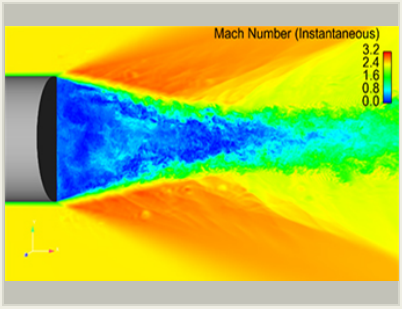

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Table of Contents

Efficient High Fidelity Computational Tool for Acoustically Driven Multiphysics Propulsion Modeling, Phase I

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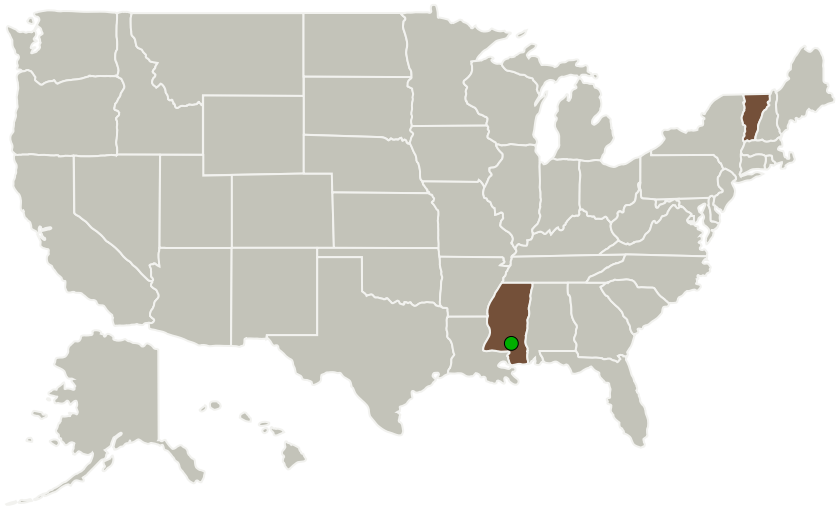
Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
Tetra Research Corporation	Lead Organization	Industry Women-Owned Small Business (WOSB)	Princeton, Illinois
Stennis Space Center(SSC)	Supporting Organization	NASA Center	Stennis Space Center, Mississippi

Primary U.S. Work Locations	
Mississippi	Vermont

Project Transitions

June 2016: Project Start

June 2017: Closed out

Closeout Documentation:

- Final Summary Chart*(https://techport.nasa.gov/file/140374)*

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Organization:

Tetra Research Corporation

Responsible Program:

Small Business Innovation Research/Small Business Tech Transfer

Project Management

Program Director:

Jason L Kessler

Program Manager:

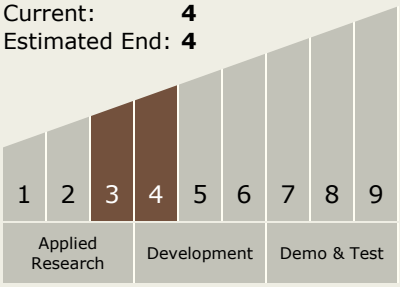
Carlos Torrez

Principal Investigator:

Robert R Chamberlain

Technology Maturity (TRL)

Start: **3**
Current: **4**
Estimated End: **4**



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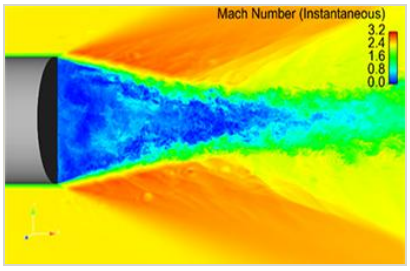
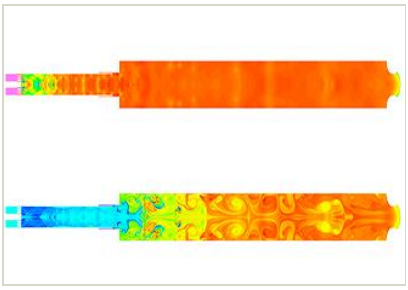
Images



Briefing Chart Image
Efficient High Fidelity Computational Tool for Acoustically Driven Multiphysics Propulsion Modeling, Phase I
(https://techport.nasa.gov/image/129441)



Final Summary Chart Image
Efficient High Fidelity Computational Tool for Acoustically Driven Multiphysics Propulsion Modeling, Phase I Project Image
(https://techport.nasa.gov/image/132478)

Technology Areas

Primary:

- TX01 Propulsion Systems
  - TX01.1 Chemical Space Propulsion
    - TX01.1.3 Cryogenic

Target Destinations

The Sun, Earth, The Moon, Mars, Others Inside the Solar System, Outside the Solar System